Model 990
Manual of Instructions

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RFL Industries, Inc.
INSTRUMENTATION DIVISION • Boonton, New Jersey, U.S.A.

Warranty

The Model 990 Magnetreater carries a warranty of 12 months from date of delivery for replacement of any part which fails during normal operation or service. Deficient parts should be returned to the factory, shipping charges prepaid, for replacement f.o.b. Boonton, N. J.

RFL Industries, Inc.

Boonton, New Jersey, U. S. A.

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Manual of Instructions

MODEL 990
MAGNETREATER®

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RFL Industries, Inc.
Boonton, New Jersey, U. S. A.

Book No. MA-25575

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Model 990 Magnetreater with Automatic Module HB-25580.

GENERAL

Scope of Manual

This Manual provides complete operating and maintenance instructions for the Model 990 and material pertaining to the Automatic Module Assembly Type HB-26100.

Mechanical Inspection

The Model 990 is carefully packed to ensure that normally rough treatment in transit will not damage it. Any damage, concealed or otherwise, should be reported immediately to the carrier with a copy to RFL Industries. Please retain cartons and packing materials until an investigation of the damages by the carrier or its insurance representative is completed.

Electrical Check

Check the electrical performance of the Model 990 as soon as possible after receipt. Refer to Test for Proper Operation of the 990 Magnetreater or Test for Proper Operation of the Automatic Module HB-25580 if applicable.

Engineering Design Service

RFL Industries maintains an Applications Engineering Section to provide design service geared to the requirements of the individual customer. This covers the design of charging, treating and measuring fixtures as well as overall complete system design. All application requirements, special or routine, pass through our Applications Engineering Section. Recommendations are made on a composite basis of economy and reliability. There is no charge for this service.

Ordering Information

The basic unit consists of the Model 990 Magnetreater plus Treat Module HB-25590. This system may be used for manual treating of magnetic systems. Type HB-26100 Automatic Module Assembly consists of the plug-in module plus a relay module with two relays, edge connector and harness. A wide range of treating coils is available. Standard stock coils are shown in the table on page 6.

Description

The Model 990 is a completly solid-state instrument having high reliability. Pulse amplitude regulation is continuous, resulting in stability of demagnetizing pulses without effects from line voltage fluctuations. Average line demand is small because of the stored energy technique; thus the Model 990 may be operated from any convenient 115 or 230 volt line source. Demagnetizing power applied to the treating fixture is continuously variable from less than 1 VA to a level in excess of 80,000 VA. In some cases, power levels as high as 140,000 VA are obtainable. Peak power depends upon the setting of the Model 990 amplitude controls (maximum EMF is 600 volts) and the impedance of the treating fixture.

The pulse rate of the Magnetreater is variable from approximately 50 pulses per minute to 200 pulses per minute. Pulse rate is dependent to some extent upon the setting of the amplitude controls. The resolution of the demagnetization control is better than 0.1%.

Amplitude of output pulses are governed by a six-position Range control and a Fine and Coarse function control. Continuous pulse trains or single shot pulses are available at the operators discretion.

The Model 990 is housed in a grey, wrap-around aluminum cover. The front panel is designed for operator convenience with a brushed aluminum and blue color combination. The instrument is easily adaptable to rack mounting by removal of the cover and side brackets. No mounting accessories are required. Bench mounted, the instrument measures 19 1/8" wide by 11" deep by 7 1/2" high. With cover and side brackets removed, the width is standard 19" rack width and occupies 7" of rack space. Depth behind the panel is 11 1/4" including any relays which may be required. Weight is 43 pounds.

TABLE 1. SPECIFICATIONS

Source:	115V or 230V (50 Hz or 60 Hz)	
Demagnetizing Power:	Variable from less than 1VA to 80 KVA - (Note in some cases levels as high as 140 KVA are obtainable).	
Pulse Rate:	50 ppm to 200 ppm.	
Resolution:	up to .1%	
Dimensions:	Bench Type	mm
	Width 19 1/8"	(486)
	Depth 11"	(279)
	Height 7 1/2"	(191)
	Rack Mount	
	Width 19 1/2"	(495.3)
	Depth 11 1/4" including relays	(283)
	Height 7"	(178)
Weight:	43 lbs. (19.50 Kg)	

Treating Coils

The Standard Coil Dimension Table shows the inside dimensions of the most widely used standard coils. Many other sizes are available for individual or special applications. Universal fixtures for some types of panel meters are given in the current price list.

The volume or dynamic level of treating flux available depends primarily on the cross sectional area

encompassed by the treating coil. Thus, a smaller "window" area will provide a higher treating flux density than will a coil with a larger area, applied energy for both coils being the same. The Model 990 is designed primarily for stabilizing magnets of the steel family; Alnico, cobalt and tungsten. It will, however, treat small volumes of the higher coercive force variety of magnets, such as cobalt platinum and barium ferrite. In the latter case, a coil having a small internal diameter is required to provide the degree of concentration of energy necessary for treating the higher coercive force material.

The type of treating coil required will depend also on the overall configuration of the structure which will be treated. It should be remembered that a rectangular coil has least overall uniformity of demagnetizing field; a high flux concentration will tend to build up in the corners. When treating a large number of magnets in production, it is advisable to fabricate a jig to enable placement of each magnet in the same physical location within the coil every time. This is to ensure that each magnet will receive similar demagnetizing force with one given setting of the Magnetreater amplitude controls. The demagnetizing force in any coil will vary depending on location with respect to the center of the coil.

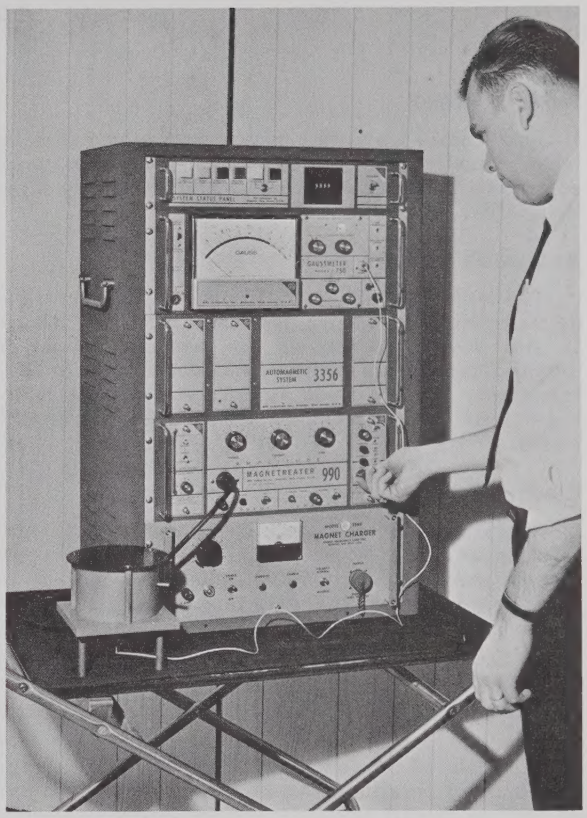
STANDARD COIL DIMENSIONS

PART NO.	*RECTANGULAR (INSIDE)*	*ROUND (INSIDE)*
HC-7010-1	2½" x 4½"	
HC-7010-2	3" x 6"	
HC-7010-3	4" x 8"	
HC-7010-16		3½" diam.
HC-7010-22		1½" diam.

Purpose and Various Applications

The Model 990 Magnetreater is a high-energy pulse type demagnetizer for precisely controlled stabilization of permanent magnets and permanent magnet assemblies. The basic theory of the demagnetization technique is similar to that inherent in the long-established Model 889 Magnetreater, i.e. a series of damped wave-pulses. Materials of the Tungsten, Chromium and Alnico groups as well as Lodex and many configurations of barium ferrite material may be treated to a desired level of flux density. The Model 990 ensures repeatability to any predetermined level.

The instrument is particularly suited for use as the calibration adjustment medium for DC indicating instruments, accelerometers, torque motors, permanent magnet field motors, traveling-wave tube magnets and a wide variety of other designs embodying permanent magnets. In some cases, the Model 990 may be used for total demagnetization.



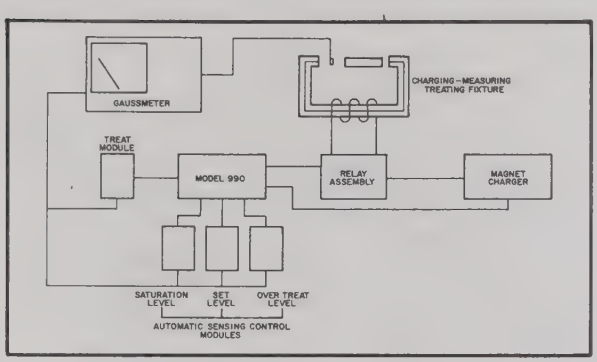
Complete Automatic Operation in System Configuration.

The Model 990 Magnetreater may be operated as a manually controlled instrument with the operator having complete control of the system; as a semi-automated system using both an operator and a flux sensing apparatus such as an RFL gaussmeter; or as a completely automated system without the need for an operator and using a gaussmeter as the sensing transducer. In some instances, the external function being monitored may not be applicable to flux density measurement; such as in calibration of meter movements. In this case photoelectric sensing or other means may be utilized with feedback to the Model 990 System.

A wide range of plug-in modules allows system versatility and is adaptable to programed remote operation. The basic Model 990 and Treating Module may be purchased and automation modules added at a later date as production requirements dictate.

The Magnetreater may be used in conjunction with the RFL Model 3265 or Model 750 Gaussmeter and any one of a wide range of RFL Magnet Chargers. The system shown is one devised for rapid and precise calibration and adjustment of individual magnets used in traveling-wave tube assemblies. In this instance, the system is semi-automated and the operator is able to set desired level. Complete automation may be achieved by the use of additional automation modules to enable sensing of saturation level and inadvertent

overtreating as well as sensing of predetermined desired level. See Block Diagram.



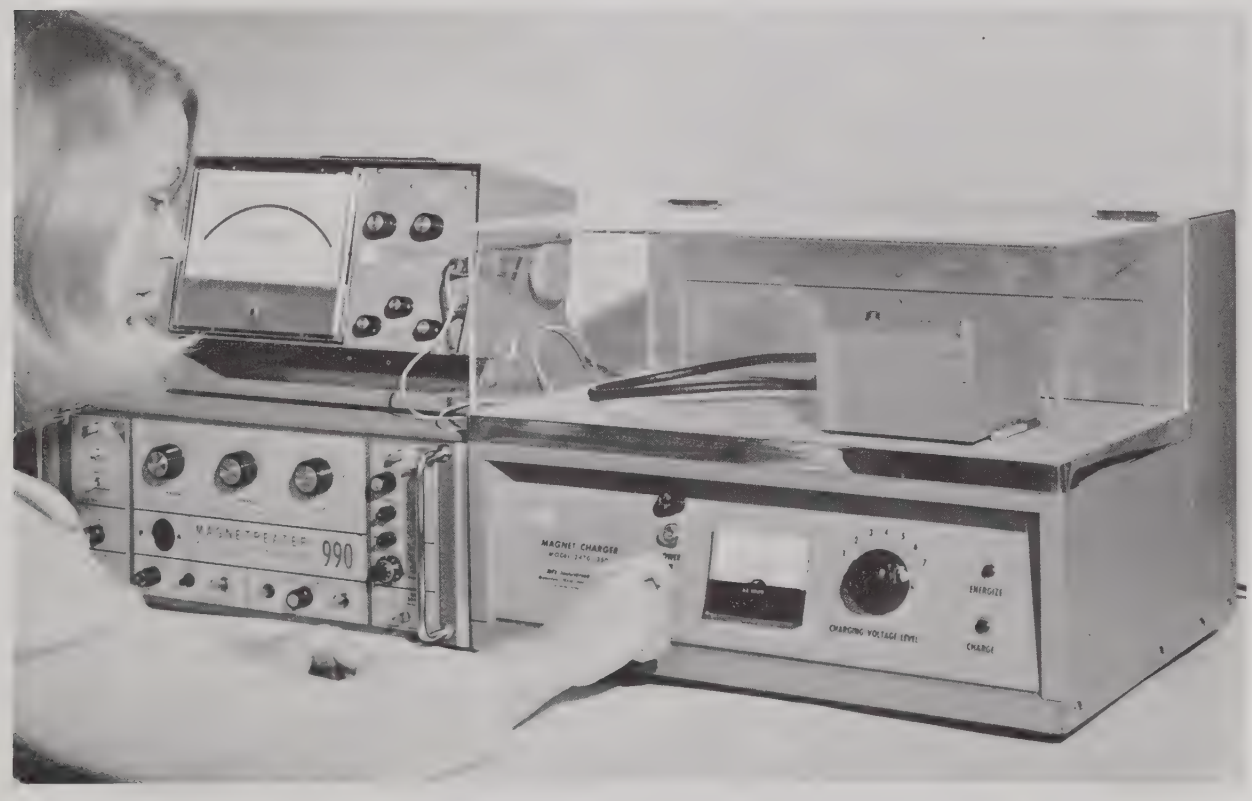
Programed System Block Diagram.

Simultaneous Treating & Measuring

When magnets are purchased in a charged state or the magnetizing process is done at another location, the Model 990 can be used with a gaussmeter to stabilize to exact levels. The RFL Hall effect Model 750 Gaussmeter indicates the flux level constantly during the treating operation. As the amplitude controls are advanced, the gaussmeter will show the decreading field between the magnet poles; when the flux reaches the desired value, treatment is stopped. In some cases a completely automatic system of stabilizing may be desirable; this can be achieved by using instrumentation as shown in the Basic System Concept Chart on Page 8.

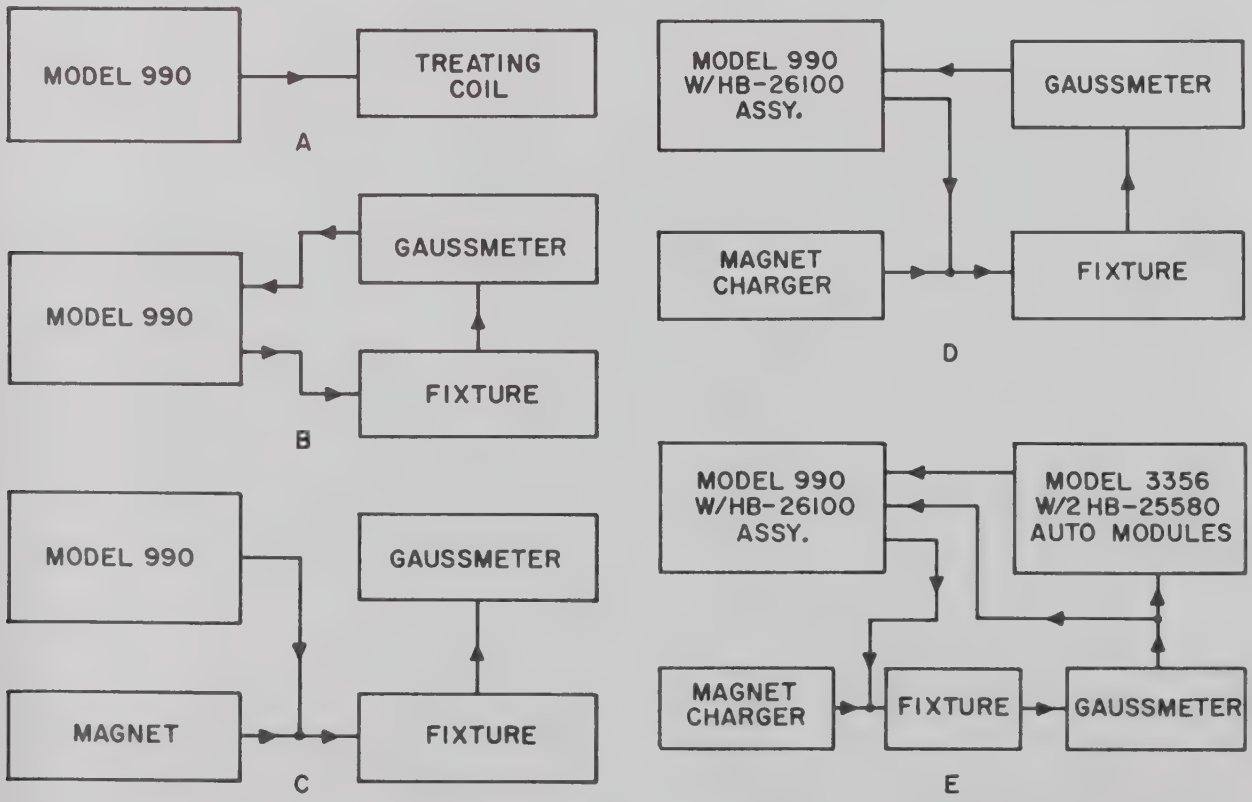
Basic System Concept

The Model 990 is a versatile instrument, with unique capabilities for system concepts. A wide variety of applications is available from a basic manual operation to complete automatic operation with the Model 990 as the control center of all systems. The following chart shows a building block concept and is to be used only as a guide. For final recommendations, please consult the RFL Magnetic Engineering Group. NOTE: All connecting cables and relays used in a system will depend upon the application.

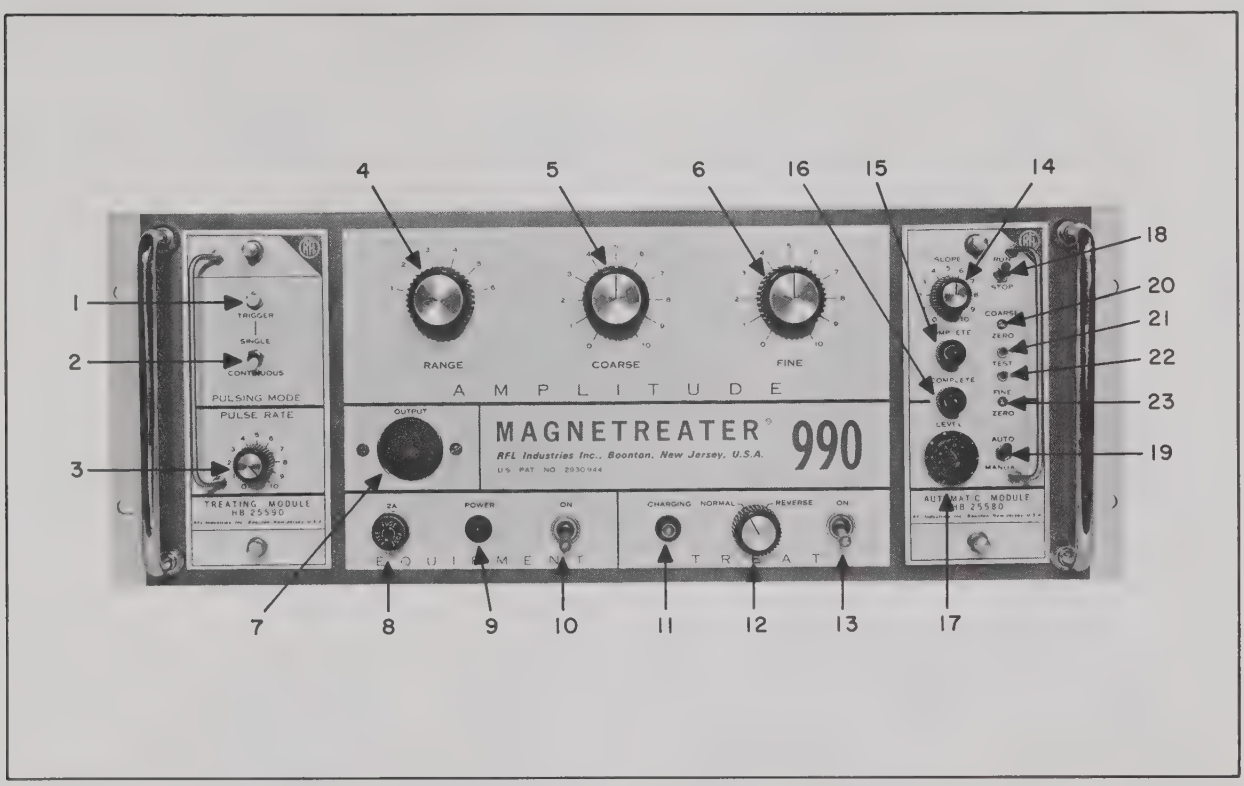


Typical System Configuration Using Model 990.

TYPE OF OPERATION	EQUIPMENT REQUIRED									
	Magnet Charger	Model 990	HB-26100 Automatic Module Assy.	Gaussmeter	Fixture	Model 3356 Automagnetic System	HB-25580 Automatic Module	Connecting Cables	Treating Coil	Basic System Outline
Treating (Manual)		X							X	A
Treating (Automatic)		X	X	X	X					B
Charging & Treating (Semi-Automatic)	X	X		X	X			X		C
Charging & Treating (Automatic)	X	X	X	X	X			X		D
Charging & Treating (Automatic) w/min. Saturation Level & Over Treat sensing	X	X	X	X	X	X	X	X		E



Basic System Concept Chart.



Front Panel View of Model 990 with Automatic Module HB-25580.

DESCRIPTION

Front Panel

1. *Trigger pushbutton:* When the Pulsing Mode switch is in single mode, a single pulse train can be initiated by this control.

2. *Pulsing Mode switch:* Selects either single or continuous operation.

3. *Pulse Rate:* Provides a variable delay between pulses.

4. *Range:* These three controls set the amplitude of
5. *Coarse:* the treating pulses.
6. *Fine:*

7. *Output:* Treating fixture receptacle.

8. *Fuse holder:*

9. *Power lamp:* Indicates unit "ON".

10. *Power Switch:* Controls AC power to instrument.

11. *Charging lamp:* Indicates that treater is cycling. Note: See maintenance section for proper operational check.

12. *Normal/Reverse switch:* Reverses the polarity of initial treating pulse.

13. *Treat ON/OFF switch:* In the "OFF" position, additional pulse trains are prevented.

Automatic Module (HB-25580)

14. *Slope:* Determines the time it takes to increase the amplitude of the treating pulses.

15. *Complete lamp:* Indicates zero field or desired set level.

16. *Incomplete lamp:* Indicates the pulse amplitude is too low and that readjustment of amplitude controls is needed.

17. *Level:* Provides adjustment for the complete level.

18. *RUN/STOP switch:* Stops treat pulses and resets integrator.

19. *AUTO/MANUAL switch:* Disables Automatic Module.

20. *Coarse Zero:* Refer to the maintenance section
21. *Test Point 1.:* of this manual in test procedure
22. *Test Point 2.:* section Step f for the proper
23. *Fine Zero:* adjustments.

OPERATION AND MAINTENANCE

Theory of Operation

The 990 Magnetreater is designed to reduce the field produced by a saturated magnet to some precise but lower value. At the lowest level of operation, the easiest magnetic domains are scrambled leaving all harder domains unchanged. As the treat level is increased, harder and harder domains are scrambled, with a corresponding reduction of flux density. The scrambling is accomplished by passing a decaying AC waveform through a treating fixture. Each succeeding ½ wave of current peaks at a smaller absolute value and in the opposite direction. For a given treating waveform, the maximum number of domains are switched on the first ½ wave; but since the second ½ wave is smaller and of the opposite polarity, the hardest domains out of those switched by the first ½ wave remain as they were, all others switch back. This process continues until the easy domains, below the treat level, are scrambled.

One treat cycle progresses as follows: Capacitors C17 and C18 are charged to certain voltages between 10 volts and 600 volts, selected by settings on the front panel. When the desired voltage is reached, charging SCR's are turned off and SCR, CR34 is gated on. This permits capacitors C17 and C18 to discharge through the treating coil. Since the capacitor and the treat coil form a resonant circuit, the current will reverse and charge the capacitors in the opposite direction through diode CR31. The AC waveform will decay due to circuit losses.

Detailed Description of Operation

Charging SCR's CR32 and CR33 conduct alternate ½ cycles of input power during the charging time. They are turned on by pulses from pulse transformer T2 which isolates control circuitry from AC power. Unijunction oscillator Q5 drives the pulse transformer, unless there is an inhibit signal from Q6. A positive signal on the base of Q6 clamps Q5 emitter to common and stops oscillation.

Switch 3AB sets the range of operation, Section A selects the transformer tap, and Section B adjusts the trigger point for Schmitt trigger Q11, Q12. COARSE and FINE controls also adjust the trigger point. When the trigger point is reached, the Schmitt trigger flips, and an inhibit signal clamps the Q5 emitter to common, stopping oscillation and thus stopping charging current through SCR's CR32 and CR33. In addition, a positive pulse from the Schmitt trigger is conducted through C11 and CR24 to the gate generator (a monostable multivibrator). During the ON time for this one shot, the output SCR CR34 is turned on allowing the capacitors C17 and C18 to discharge through the treating coil. In addition, an inhibit signal is applied to Q6 which prevents input charging current for the duration of the gate. The gate remains open for about 100 milliseconds, unless the gate stretcher capacitor from the Automatic Module shunts the timing capacitor C12. A third signal occurring at the end of the gate triggers a second monostable multivibrator (Q17 and Q18) which provides a variable delay. As long as this one shot is turned on, another inhibit signal clamps the emitter of Q5 and prevents input charging current. Front panel control R50, is used to adjust the pulse rate. If the delay generator is allowed to turn off, all inhibit signals have been removed from the emitter of Q5 and charging of C17 and C18 starts again. Provision has been made to prevent Q17 and Q18 to turn off by grounding the junction of CR28 and CR29. This is the method of interrupting the cycle and is used by the TREAT ON-OFF switch, external control circuitry and when a single treating train is desired. When a single train is desired, C16 having been charged to +12 volts, is routed into the base of Q18 by momentary switch S5. This allows the one shot to turn off long enough for a single treating cycle to occurr. Many of the control points have been terminated on barrier strips A and B providing an excellent degree of flexibility for system hook-up.

Function of Front Panel Controls

Plug a treat coil or treat coil with adapter into output receptacle on front panel. Turn PULSING MODE switch to CONTINUOUS and turn AMPLITUDE controls to full CCW. Switch TREAT switch ON. Plug-in Model 990 and turn on POWER switch. POWER lamp should light. Turn AMPLITUDE controls up to desired level. Normally the CHARGING light will be flashing indicating that treater is cycling.

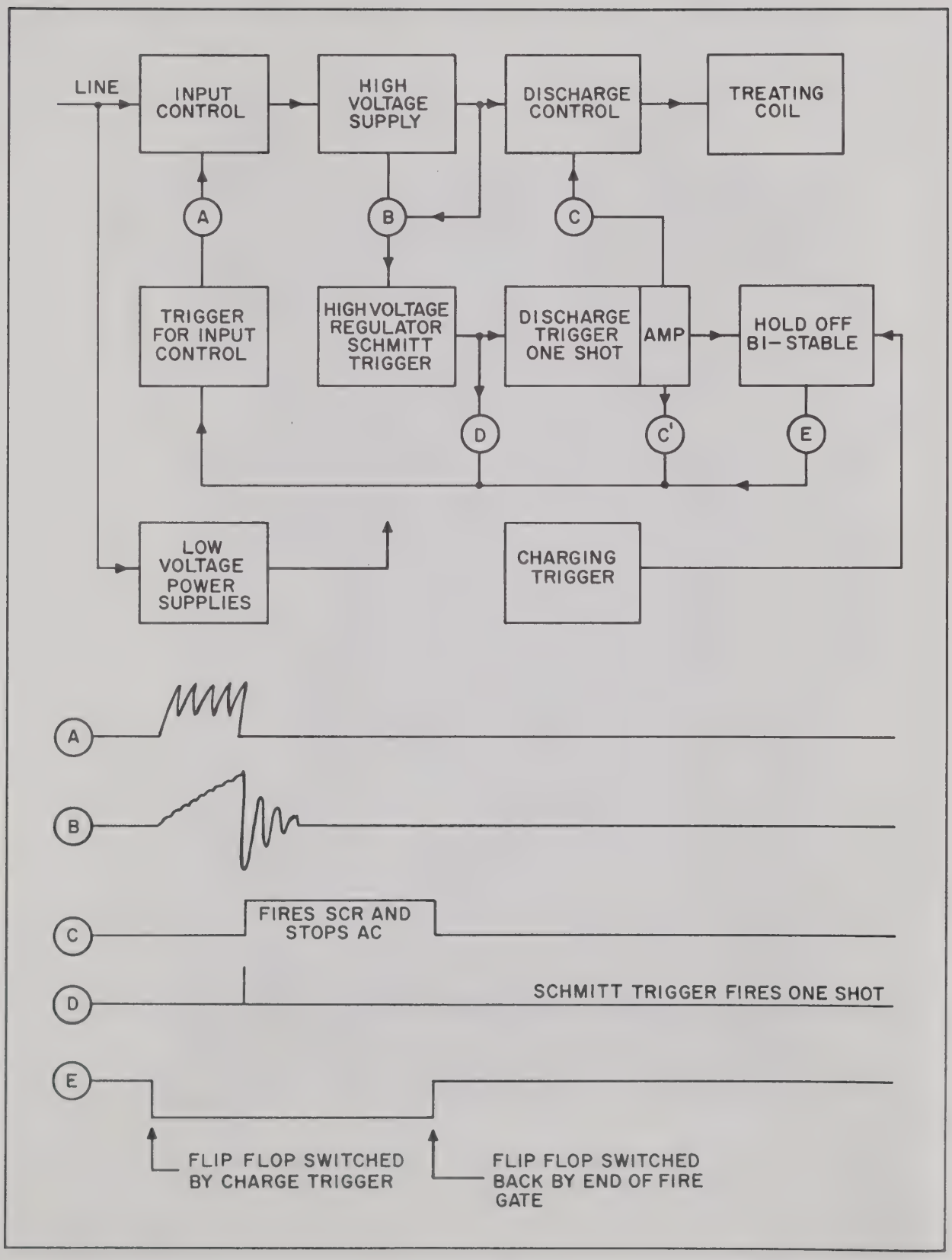
There are various means of flux density measurements. If a gaussmeter is being used, the Model 990 AMPLITUDE controls can be advanced until the desired treatment has been obtained. If meters are being calibrated, the correct current is passed through the meter and the treating controls advanced until the meter reads full scale.

Another front panel control is the PULSE RATE control which provides a variable delay between pulses. If this delay were not present, small treating pulses would occur at a very fast rate, and over treating might occur. This control would be adjusted for the maximum rate consistant with an acceptable variation in the product. When treating is complete, the TREAT switch is turned off to prevent additional pulse trains. If the PULSING MODE switch is set to SINGLE, the Trigger push button will initiate a single treat cycle.

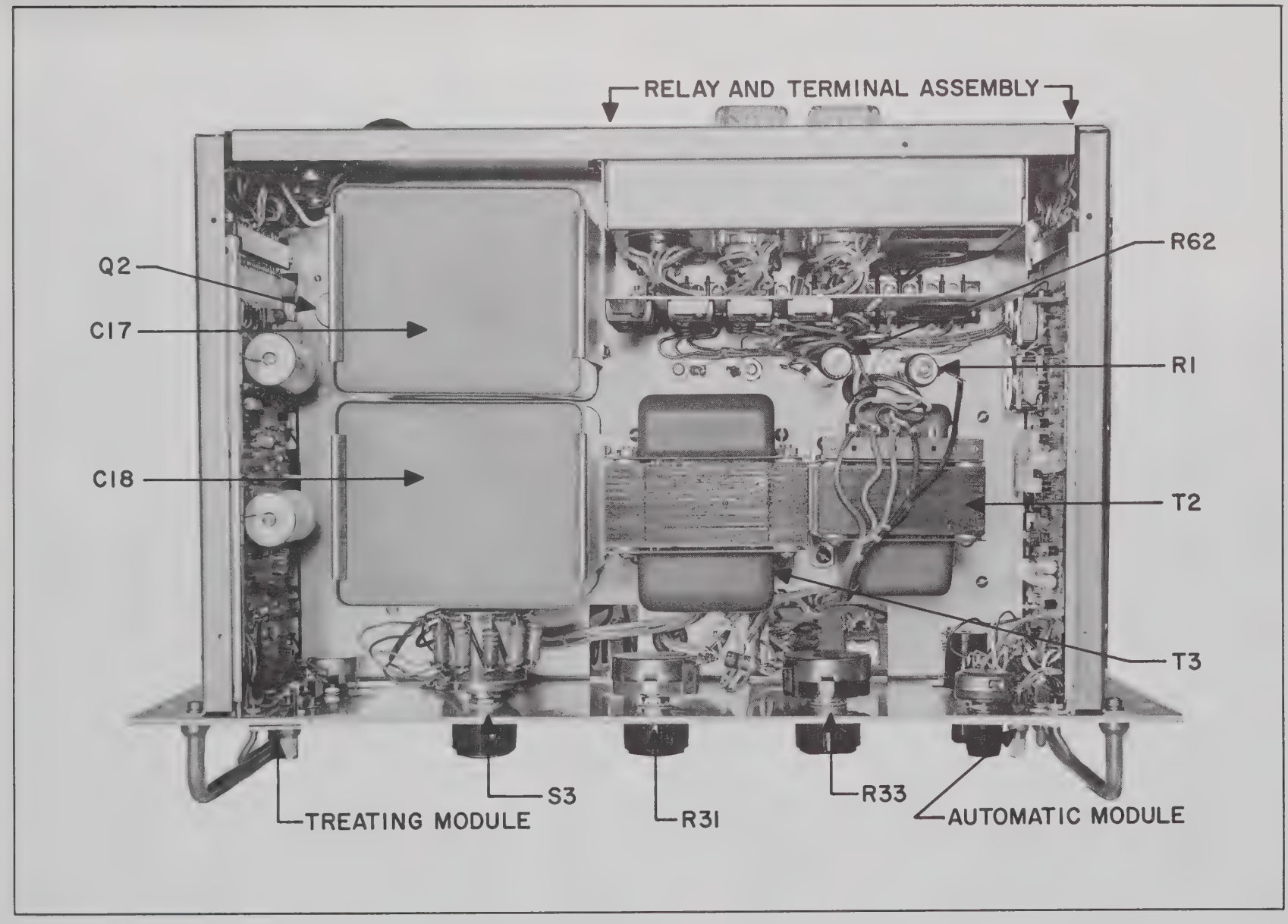
Test for Proper Operation of 990 Magnetreater

Turn RANGE, COARSE, and FINE controls full CCW. Set TREAT to NORMAL and ON. Set PULSING MODE to CONTINUOUS, power ON. Hold 750 Gaussmeter probe by the pole of a saturated magnet which will be treated down. Note the flux reading. Turn up the AMPLITUDE controls until flux reduces to the desired level.

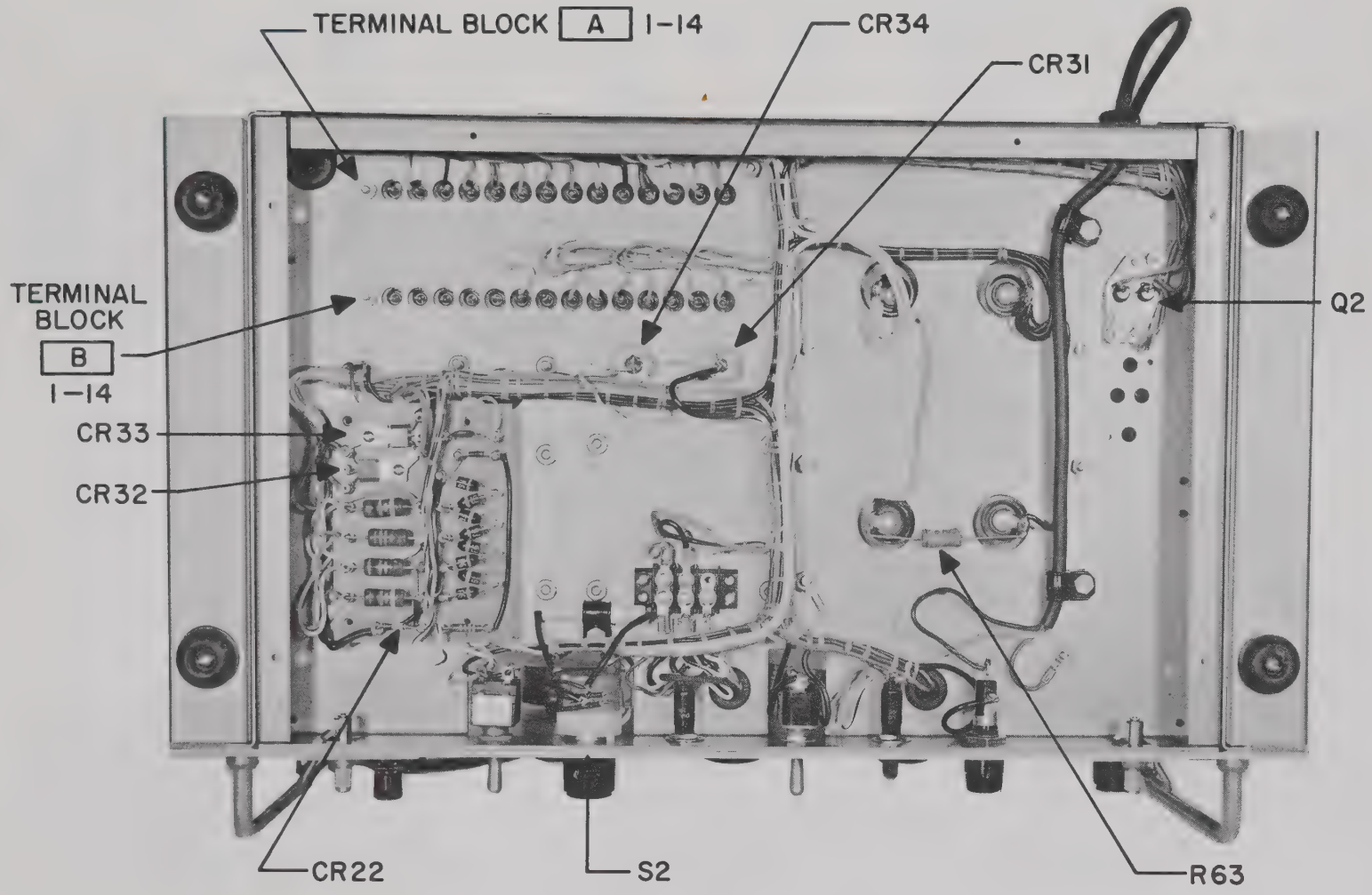
With RANGE set to 4, note that both electrodes of the CHARGING light are lit. Adjust PULSE RATE. Note that blinking of CHARGING light varies from about once per second to three times per second.



Simplified Block Diagram of Model 990 Magnetreater with Typical Waveforms.



Model 990 Magnetreater, Top View.



Model 990 Magnetreater, Bottom View.

Switch MODE to SINGLE. Pulsing should stop, hold TRIGGER down. Only one pulse should occur. Release TRIGGER, reverse TREAT switch, and hold down again, only one pulse should occur. Return PULSE MODE switch to CONTINUOUS. Turn all AMPLITUDE controls to maximum full CW. Note that charging time is much longer than previously. If the line is low, the CHARGING light might remain on. In that event, turn COARSE control CCW, pulsing should resume. Turn AMPLITUDE controls full CCW. The duration of the charging time, length of flash, should decrease greatly. In the event that the smallest pulses are still too large for some special purpose, they may be reduced by removing the jumper between A5 and A6. This reduces the maximum pulse amplitude available.

Troubleshooting Hints

If the treat coil presents a short circuit to the Model 990, the peak current will exceed 2000 amperes which can destroy the output SCR CR34., When this occurs, both sides of the CHARGING light, which is a neon, will remain lit. If only one of the electrodes of the CHARGING light remains lit, one of the input SCR's, CR32 and CR33 may be shorted. Ground collector of Q6 and if electrodes are still lit, check Q5 and SCR's, CR32 and CR33. If one electrode does not light, one input SCR is not turned on or is open. If the Model 990 is operating and treat coil is intermittent, the coil may open during peak current, thus building up a high voltage from the inductive kick. If this is immediately closed, the high voltage can destroy the output SCR, CR34.

If excessive current is taken from the +12 volt supply for driving relays or other purposes, Q4 may fail by shorting or opening. If Q4 shorts, raw positive voltage will appear at terminal block A7. (+20V)

If the output waveform is a single pulse not going negative instead of a decaying AC waveform, CR31 may be open or R62 shorted.

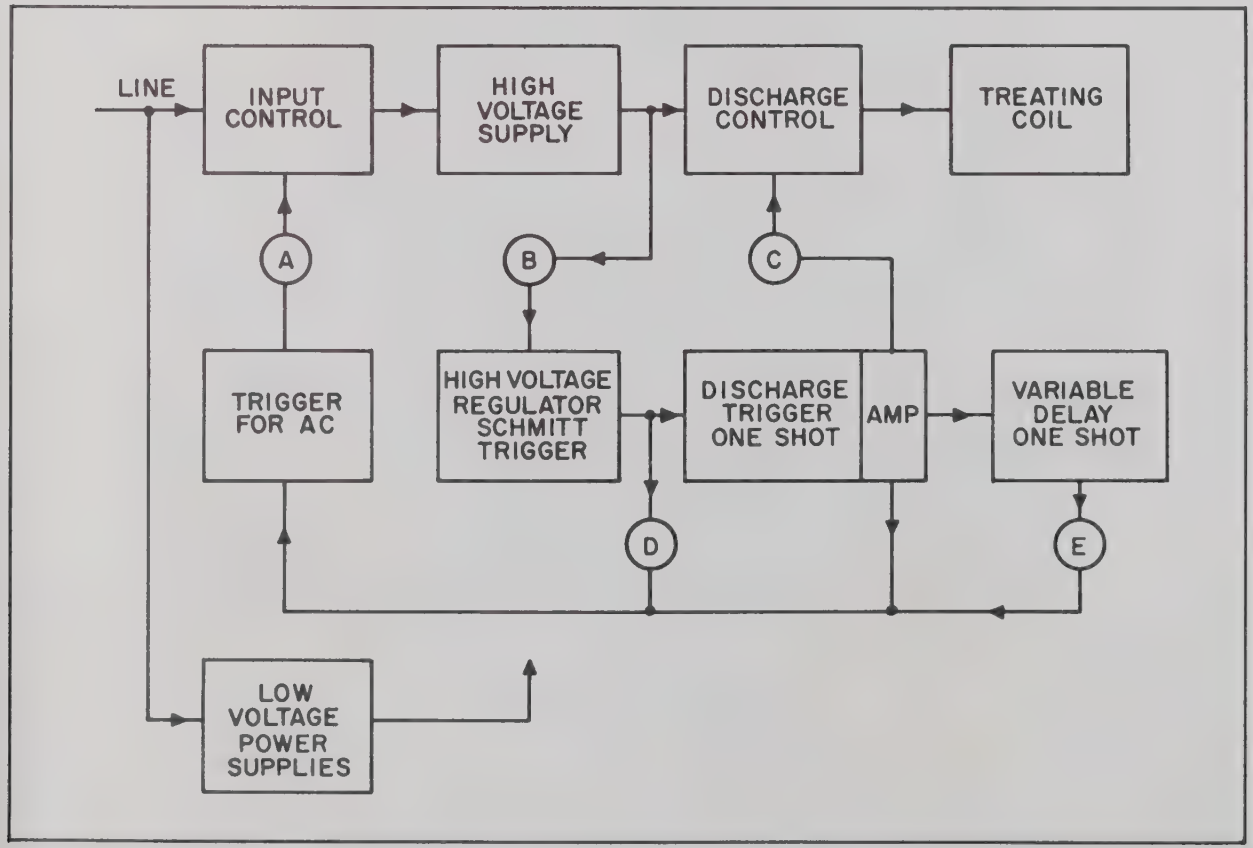
If I2 CHARGING light won't light, and set is inoperative, check that PULSING MODE switch S4 is not shorted (with POWER OFF). Also check continuity of treat fixture and connectors.

If PULSE RATE control has no affect at low amplitude, check Q17 and associated circuitry.

If C17 and C18 do not charge to about 550 volts, R34 may not be returned to -12 volts. This is a strapping option used when the Automatic Module is not installed.

NOTE

USE CARE IN TESTING SINCE LETHAL VOLTAGES ARE PRESENT INSIDE DUST COVER.



Solid State Model 990 Magnetreater Block Diagram.

CONDITIONS OF WAVEFORMS

An RFL Industries' Model 990 Magnetreater, a Treat Coil, (HC-7010-2) and a Hewlett-Packard Oscilloscope (Model 130B or equivalent) was used to obtain the following waveforms. (Note: Scope is floated to line).

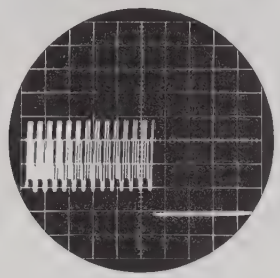


FIGURE A

Turn power off, remove Module HB-25580 (if applicable) and connect A5 to A6 with a jumper (refer to schematic).

Model 990

Range	3
Coarse	5
Fine	5
Treat	ON
Pulse Rate	CW
Pulsing Mode	Continuous
Normal/Reverse	Normal
Power	OFF

Oscilloscope

Vertical Sen.	2V/cm
DC Coupled Reference	Baseline 3cm below center graticule line.
Sweep time	20 ms/cm
Sweep	Int. x 1
Sweep Mode	Preset
Sync	Int.
Slope	+

Connect Oscilloscope leads to the collector of Q6 and Common. Turn the Model 990 Power switch ON and adjust Level control on oscilloscope for a stable display.

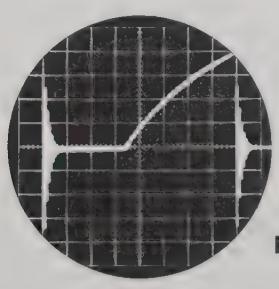


FIGURE B

Refer to conditions of Fig. A and change:

Model 990

Range	5

Oscilloscope

Reference	Center graticule
Sweep time	50 ms/cm
Vertical Sen.	50V/cm

Connect scope leads to R63 and Common. Turn the Model 990 Power switch ON and adjust Level control on oscilloscope for a stable display.

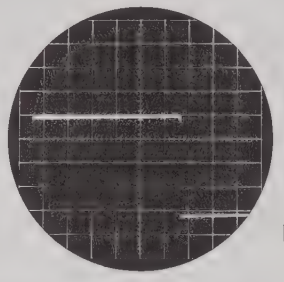


FIGURE C

Refer to conditions of Fig. A.

Connect scope leads to emitter of Q16 (Pin 11 of Treating module) and Common. Turn the Model 990 Power switch ON and adjust Level control on oscilloscope for a stable display.

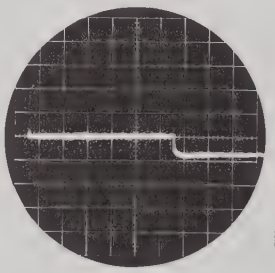


FIGURE D

Refer to conditions of Fig. A and change:

Oscilloscope

Reference	Center graticule
Vertical Sen.	5V/cm

Connect scope leads to base of Q13 and Common. Turn the Model 990 Power switch ON and adjust Level control on oscilloscope for a stable display.

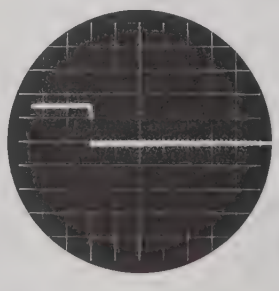


FIGURE E

Refer to conditions of Fig. A and change:

Oscilloscope

Reference	Center graticule
Vertical Sen.	5V/cm

Connect scope leads to collector of Q18 and Common. Turn the Model 990 Power switch ON and adjust Level control on oscilloscope for a stable display.

MODEL 990 MAGNETREATER TEST PROCEDURE and Automatic Module HB-25580 (If applicable)

1. Test Equipment Required.
   a. Volt-ohmmeter - 20,000 Ohms/Volt DC; 5000 Ohms/Volt AC.
   b. Oscilloscope - H.P. Model 130B or equivalent.
   c. Test Coil - 200 turns #14 SCC copper wire, 7½ layers, 2-inch ±¼ inch axial length, 4¾ inches ±¼ inch diameter.
   d. RFL Model 750 Gaussmeter or equivalent.
   e. Model 990 Magnetreater.
   f. General Radio 5-Ampere Variac or equivalent.

NOTE

USE CARE IN TESTING SINCE LETHAL VOLTAGES ARE PRESENT INSIDE DUST COVER.

2. Procedure
   a. Preliminary Check
      1. Check for continuity from grounding pin of line plug (P1) to Model 990 Magnetreater case using ohmmeter X1 resistance range. Place ON-OFF switch in both positions while making this check.
      2. Check for lack of continuity from each side of line plug (not grounding pin) to Magnetreater case. Place ON-OFF switch in both positions while making this check.
      3. Connect test coil (See 1.c above to treating OUTPUT receptacle of Model 990. Connect Model 990 to 115-volt, 50/60 Hz line through variable transformer (See 1.f above). Set variable transformer to apply 115 volts to the Model 990. Model 990 POWER switch should be in OFF position; TREAT switch in OFF position; and output polarity in NORMAL.

   b. Wave Shape Check
      1. Float Model 130B Oscilloscope to line. Connect common to the black lead on C17; connect the red vertical input terminal to the yellow lead on C17; set Vertical Sensitivity to 50 V/cm; set Input switch to DC; set Horizontal Deflection to Internal Sweep x 1, Vernier to Calibrate. Set Sweep to 5 ms/cm, Vernier to Calibrate; Sync to Internal +; Level, as required to stabilize signal.
      2. Set Model 990 PULSING MODE to CONTINUOUS. Set PULSE RATE to 10; set AMPLITUDE RANGE to 5; COARSE to 5; FINE to 5. Set TREATING to NORMAL, and to ON; set POWER switch to ON. Observe that waveform is a damped sinusoid as in Fig. 1.

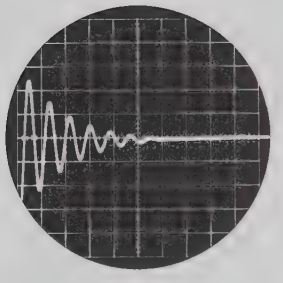


FIGURE 1

3. Switch Model 130B Oscilloscope Sweep to 50 ms/cm. Observe the capacitor charge curve. The small 120 Hz ripple should be uniform. Turn Model 990 TREAT to OFF.

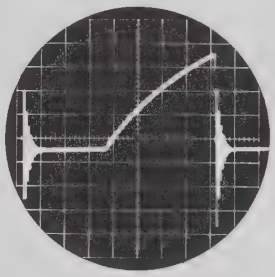


FIGURE 2

   c. Peak Amplitude Check
      If the Automatic Module is installed, check that jumper A5 to A6 has been removed. Set AUTO/MANUAL switch to MANUAL. If the Automatic Module is not installed check that jumper A5 to A6 has been installed. Set the AMPLITUDE RANGE to 6; COARSE to 10; FINE to 10. Connect Multitester (1000V range) across C17. Turn TREAT ON. Note that peak voltage exceeds 600 volts but is less than 700 volts. Turn TREAT to OFF. Disconnect Volt-ohmmeter leads.

   d. Range Overlap Check
      1. Set Model 990 AMPLITUDE RANGE to 6; COARSE to 0; FINE to 0. Set Model 130B Oscilloscope to External Sweep; Vertical Sensitivity to 20 V/cm; Vernier full CCW. Position peak to center of oscilloscope screen. Set Model 990 AMPLITUDE RANGE to 5; COARSE to 10; FINE to 10. Peak must be higher than center of screen.
      2. Set Model 990 AMPLITUDE RANGE to 5; COARSE to 0; FINE to 0. Set Model 130B Oscilloscope Vertical Sensitivity to 10 V/cm and adjust peak to center of screen. Set Model 990 AMPLITUDE RANGE to 4; COARSE to 10; FINE to 10; Peak must be higher than center of screen.
      3. Set Model 990 AMPLITUDE RANGE to 4; COARSE to 0; FINE to 0. Set Model 130B Oscilloscope Vertical Sensitivity to 5 V/cm, position peak to center of screen. Set Model 990 RANGE to 3; COARSE to 10; FINE to 10. Peak must be higher than center of screen.

4. Set Model 990 AMPLITUDE RANGE to 3; COARSE to 0; FINE to 0. Set Model 130B Oscilloscope to 2 V/cm, position peak to center of screen. Set Model 990 RANGE to 2; COARSE to 10; FINE to 10. Peak must be higher than center of screen.

5. Set Model 990 AMPLITUDE RANGE to 2; COARSE to 0; FINE to 0. Set Model 130B Oscilloscope to 1 V/cm, position peak to center of screen. Set Model 990 AMPLITUDE RANGE to 1; COARSE to 10; FINE to 10. Peak must be higher than center of screen.

e. Check of Control Functioning.
Set the Model 990 AMPLITUDE RANGE to 5; COARSE to 5; FINE to 5. Check that TREAT ON/OFF switch stops CHARGING light and pulsing when in the OFF position. Check that PULSING MODE switch stops CHARGING light and pulsing when it is in the SINGLE position. Check that each depression of the TRIGGER produces only one pulse train. Set Model 990 PULSING MODE switch to CONTINUOUS. Vary PULSE RATE from zero to ten. Observe a change in pulse rate of about three to one. This may vary from 30 pulses per minute to 160 pulses per minute.

f. Check of Automatic Module
Set the Model 990 AMPLITUDE RANGE to 5; COARSE to 5; FINE to 5. Set AUTO/MANUAL switch to AUTOMATIC. Connect Multitester (10-volt range) to TEST 1 and TEST 2. Switch RUN/STOP switch to STOP. Adjust COARSE ZERO for minimum reading on meter. Set SLOPE to 0. Remove test leads. Adjust FINE ZERO for 20 ±5 seconds interval between switching RUN/STOP switch to RUN and lighting of red INCOMPLETE light (clockwise increases time).

Observe that green COMPLETE light turns ON when RUN/STOP switch is in STOP position. Observe that green COMPLETE light turns on when LEVEL control is turned from 999 toward 800. Set SLOPE to 10. Time interval between switching to RUN and lighting of red INCOMPLETE light should be less than 5 seconds.

NOTE

Do not use self-fabricated fixtures; coils must be designed to meet proper impedance and voltage requirements. Contact factory Engineering Design Service for assistance.

Resistance and Voltage Tables

The following tables are to be used as a guide to locate faulty components or circuitry. It should be noted that all the data in the tables are typical values and will vary slightly with each unit. The user of such tables should use his own judgment when discrepancies are noted. The tables are comprised to aid in service and repair of the 990 Magnetreater. A Simpson Model 260 (or equivalent) is to be used as the test instrument.

990 MAGNETREATER RESISTANCE TABLE
Resistances measured between board fingers and Common on board.

PIN	FUNCTION	POSITIVE	NEGATIVE
1	Mode	3.7K	16K
2	-12 Volts	1.5K	2.6K
3	Trigger	55K	62K
4	Treat Off	150K	∞
5	-12 Drive	2.4K	2.3K
6	Unregulated (-)	5.2K	4.8K
7	AC Power	10K	10K
8	AC Power	10K	10K
9	Common	0	0
10	Unregulated (+)	5.1K	1.2K
11	Gate	12K	4.2K
12	CR32 Cathode	∞	∞
13	CR33 Cathode	∞	∞
14	CR33 Gate	∞	∞
15	CR32 Gate	∞	∞
16	Low Flux Inhibit	20K	∞
17	+12 Volts	1.4K	3.4K
18	Amplitude Control	7.0K	300K
19	Not Used		
20	Gate Stretcher	2.7K	5.7K
21	Gate Stretcher	1K	80K
22	Charging Lamp	∞	∞

990 MAGNETREATER RESISTANCE TABLE

Conditions of Measurements: All measurements are made on the printed circuit board while it is unplugged. Pulse rate set maximum CW, Mode switch on continuous, all readings taken with respect to common, ± indicates lead polarity. (Test instrument Simpson 260 or equivalent).

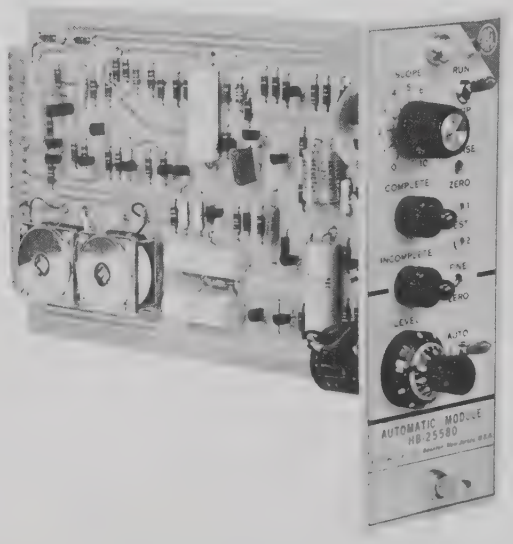
TRANSISTOR	EMITTER		BASE		COLLECTOR	
	POS.	NEG.	POS.	NEG.	POS.	NEG.
Q1	2.3K	2.3K	3K	4.7K	6K	4.8K
Q3	940Ω	3.6K	1.5K	1.8K	3K	4.8K
Q4	1.4K	3.5K	5.2K	850Ω	5.1K	1.2K
Q5	7K	1.4K	2.5K	2.8K	0	0
Q6	0	0	960Ω	2K	2.2K	2.7K
Q10	1.1K	52K	5K	300K	1.4K	3.3K
Q11	47Ω	47Ω	1.1K	52K	1K	10K
Q12	47Ω	47Ω	1K	10K	3.4K	10K
Q13	47Ω	47Ω	1.1K	2.5K	2.6K	5.6K
Q14	2K	2K	2.6K	5.6K	1.4K	3.4K
Q15	47Ω	47Ω	1.1K	80K	4K	7K
Q16	12K	4.2K	4.5K	12K	1.4K	3.4K
Q17	0	0	1K	2.4K	5K	7K
Q18	0	0	970Ω	12K	4.2K	6.8K

990 MAGNETREATER VOLTAGE TABLE

Conditions of Measurements: All voltages referenced to common. All controls turned maximum CW and Treat switch off.

TRANSISTOR	EMITTER	BASE	COLLECTOR
Q1	-10.5	-11.5	-19
Q2	-10.5	-10.5	-20
Q3	-6.7	-7.4	-11.5
Q4	+10.5	+11	+19
Q5	+8	0	+0.14
Q6	0	+0.7	+0.14
Q10	-5.4	-4.7	+10.5
Q11	+0.19	-5.4	+0.9
Q12	+0.19	+0.9	+0.23
Q13	+0.22	+1	+10.5
Q14	+9.5	+10	+10.5
Q15	+0.22	+0.92	+0.36
Q16	-0.29	+0.1	+10.5
Q17	0	+0.69	+0.2
Q18	0	-0.35	+8.1

CAUTION: High voltage present inside dust cover.



Automatic Module HB-25580.

AUTOMATIC MODULE HB-25580

General

Type HB-26100 Automatic Module Assembly consists of the plug-in module, plus a relay module with two relays, edge connector and harness. The Automatic Module is used in conjunction with the 990 Magnetreater and a gaussmeter such as the Model 750. A saturated magnet is placed in the treating fixture. The gaussmeter probe is accurately positioned with respect to the magnet. After the controls have been set, pulses from the Model 990 gradually increase in amplitude causing the flux from the magnet to gradually decrease. When a predetermined level has been reached, the treating stops and a COMPLETE light turns on. It remains lit until another saturated magnet is placed in the fixture.

Details of Operation

The COMPLETE light is ON, a saturated magnet is placed in the fixture next to the probe. The gaussmeter reads and puts out a DC 0 to ±3V signal. This current is added to a current from a high resolution ten-turn potentiometer, R103. The sum is applied to the input of the DC level amplifier. The output of the DC level amplifier turns off COMPLETE light, starts out negative and progresses in a positive direction when it reaches positive 1.7 volts, the complete Schmitt flips, operating complete relay R102, turning on COMPLETE light and clamping both ends of C107, C108 to common. This function also provides an inhibit signal to Q5 and thus interrupting the charging cycle. We need to backtrack to the time when the output of the DC level amplifier went negative or below positive 1.7 volts. At that time, the clamps on the integrating capacitor C107, and C108 were released. This permitted integrating amplifier Q105 through Q110 to generate a linear ramp in the negative going direction. This voltage is applied through R34 to the input of Schmitt trigger Q11, Q12, in the Model 990. As the ramp becomes more negative, C17 and C18 will charge to higher voltages before the firing point is reached. The increasing amplitude treats the magnet further down as long as the desired flux level has not been reached, and the integrator can supply a negative going ramp. Just before the integrator saturates a third Schmitt trigger (incomplete) flips and activates the incomplete relay and light. This relay does not operate in the normal chain of events since the complete relay will function and prevent it.

Front Panel Controls

On the Automatic Module are the ten-turn potentiometer R103 used to set the trip level for the complete relay, R121 (SLOPE) which controls how fast the integrator charges C107 and C108, and thus how rapidly the treating pulse amplitude increases, R119 and R134 adjust the initial voltage condition across C107 and C108 when clamps are released and the current in the Q109 and Q110 circuitry while the integrator is clamped. I102 green indicator operates when the complete relay is turned on and indicates proper treating. I101 INCOMPLETE light is red and indicates when the incomplete relay has operated. This means that the Model 990 cannot increase treat pulse amplitude further as the integrator has saturated.

Initial Setup Procedure for the Automatic Module

Set AMPLITUDE controls to minimum and set SLOPE mid position.

Since the Automatic Module is a resistive load on the 750 Gaussmeter output, the gaussmeter should be calibrated with a reference magnet and zero gauss chamber after the output is connected to the system. The TREAT ON-OFF switch is turned off to prevent accidental degaussing of the standard. The probe and standard are inserted in the fixture. The gaussmeter will read the standard. Adjust R103 slowly until the COMPLETE light just turns on. Remove the standard magnet from the fixture and replace with a saturated work piece. Turn the TREAT switch ON and allow to run until the INCOMPLETE light lights. Increase the Model 990 AMPLITUDE controls gradually until treating occurs down to the desired level.

Slope Control

With SLOPE settings minimum CCW, the increase in amplitude will progress very slowly but the treatment will yield the most precise results. Conversely, with maximum SLOPE setting, the amplitude will increase very rapidly giving the shortest treat cycle but also the greatest variation in the level of the treated product. Adjustment of SLOPE will give the best trade off between accuracy of the product and shortness of treating cycle.

Test for Proper Operation of the Automatic Module

Assuming that the Automatic Module, harness and relay deck have been correctly wired into a functioning Model 990, set SLOPE to 5, connect 750 Gaussmeter output with common on barrier terminal A3 and signal lead on B1 unfiltered to B2 filtered input lead on the Model 990. Set AUTO/MANUAL switch to MANUAL, COMPLETE light lights. SLOPE, LEVEL and RUN/STOP switch will have no effect on operation. All the regular Model 990 controls will function normally.

Turn AUTO/MANUAL switch to AUTO. Switch RUN/STOP to RUN, place 750 Gaussmeter probe in field of magnet. Adjust LEVEL control so COMPLETE light goes out. Wait until INCOMPLETE light comes on (2 to 30 seconds), turn RUN/STOP switch to STOP and back to RUN. The INCOMPLETE light should go out while a new ramp is generated. Adjust SLOPE to full CW, reset integrator by flicking the RUN/STOP switch to STOP and back to RUN, the INCOMPLETE light should come on in about 3 seconds. Set SLOPE to full CCW, attach Simpson 260 Multitester or equivalent to test points 1 and 2. Set meter to 10 volt range. Set RUN/STOP switch to STOP and adjust COARSE ZERO for zero. This is not very critical and may be offset in the positive direction to provide a longer ramp. Switch RUN/STOP to RUN and the FINE ZERO control for the desired minimum slope, greatest ramp duration. Typically, this might be 30 seconds. Set SLOPE to 5. Set the Model 990 AMPLITUDE controls to minimum. Place magnet to be treated and gaussmeter probe in treating fixture, INCOMPLETE light should be on. Gradually advance the Model 990 AMPLITUDE

controls until magnet is treated down to desired level. Advance the AMPLITUDE controls somewhat beyond this point. Recharge the magnet, switch the RUN/STOP switch to STOP. Place reference magnet next to probe, adjust LEVEL so COMPLETE light just comes on. If no reference magnet is available, the gaussmeter can be varied through the desired reading and the LEVEL control adjusted so the COMPLETE light just comes on at the desired reading. If this method is used, the gaussmeter will have to be re-calibrated while connected to the circuit. The Automatic Module applies a resistive load to the 750 Gaussmeter output which is compensated for with the calibration controls. Assuming that the gaussmeter probe is positioned safely in the fixture, a series of saturated magnets when placed in the fixture will be treated to the desired level without touching any controls.

Automatic Module HB-25580 Test Point #2

Conditions of Measurement: Insert treat coil to Model 990 output receptacle (front panel). Connect test instrument (H/P 130B Oscilloscope) leads to TP2 and Common TP1.

Model 990

Trigger	continuous
Pulsing rate	5
Range	5
Coarse	5
Fine	5
Charging	Normal
Power	ON

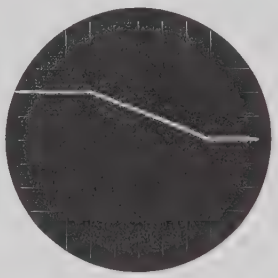
HB-25580

Slope	5
Level	CW
Auto/Manual	Auto
Run/Stop	To Stop

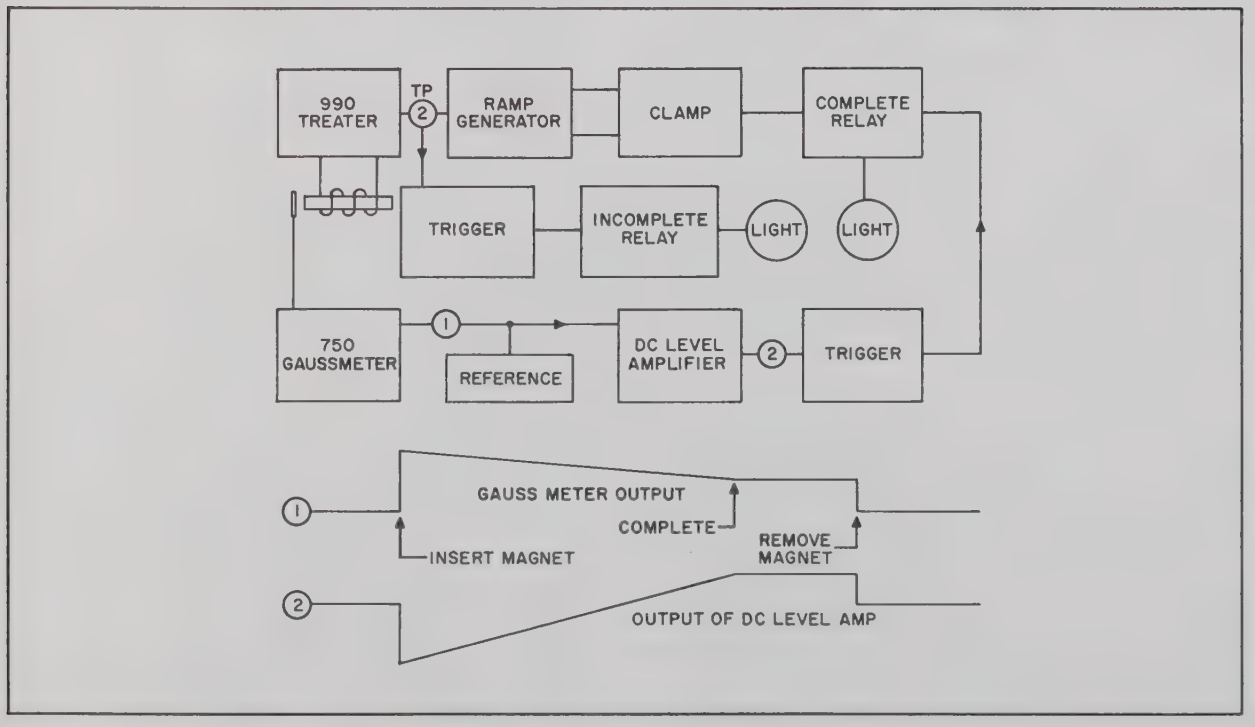
Scope

Scope	Floated to line
Vert Sen.	5V/cm
DC coupled	
Trigger slope	+
Level	0
Sweep time	1 sec./cm
Reference	Center graticule line
Sweep mode	Free run
Sync	Internal

NOTE: Switching Run/Stop switch to Run will initiate the scope trace and a decaying waveform typical to photo will be observed.



TP2



Automatic Module Block Diagram.

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Resistance & Voltage Tables for Model HB-25580 Automatic Module

The following tables are to be used as a guide to locate faulty components or circuitry. It should be noted that all the data in the tables are typical values and will vary slightly with each unit. The user of such table should use judgment when discrepancies are noted. The tables were comprised to aid in service and repair of the Automatic Module.

Conditions of Measurement: Remove HB-25580 from the Model 990. AUTO/MANUAL switch to AUTO. RUN/STOP switch to RUN. Test instrument Simpson 260. All resistances measured with respect to common.

AUTOMATIC MODULE HB-25580 RESISTANCE TABLE
Resistances measured from circuit board fingers to Common.

PIN	CIRCUIT	POSITIVE	NEGATIVE
1	Gate Stretcher	∞	∞
2	Gate Stretcher	∞	∞
3	Inhibit	3.3K	4.4K
4	-12 Volts	1.5K	1.5K
5	Filter in	18K	21K
6	Unfiltered in	16K	20K
7	Common	0	0
8	Reference Option	150Ω	1.3Ω
9	Not used	∞	∞
10	Gate	13K	13K
11	Relay Complete	3.3K	4.7K
12	Not used	∞	∞
13	Integrater out	7K	2.9K
14	Relay Incomplete	∞	13K
15	+12 Volts	1.6K	2.1K
16	Stop	8.5K	8.5K
17	Not used	∞	∞
18	Not used	∞	∞
19	Indicator complete	∞	∞
20	Indicator incomplete	∞	∞
21	Indicator common	∞	∞
22	Not used	∞	∞

AUTOMATIC MODULE HB-25580 RESISTANCE TABLE

TRANSISTOR	EMITTER		BASE		COLLECTOR	
	POS.	NEG.	POS.	NEG.	POS.	NEG.
Q101	11K	2K	4K	10K	2.8K	3K
Q102	11K	2K	1.8K	2.1K	5.1K	2.5K
Q103	1.7K	2.1K	5.2K	2.4K	3.4K	3.4K
Q104	2.5K	2.5K	2.7K	2.8K	3.4K	3.4K
Q105	11K	2.2K	6.5K	4.3K	2.6K	2.2K
Q106	11K	2.2K	1.8K	2.1K	5.2K	2.3K
Q107	1.6K	2K	5.2K	2.3K	4.4K	50K
Q108	2.5K	2.5K	2.8K	2.8K	100K	3.5K
Q109	6.5K	2.9K	4.5K	45K	1.5K	1.9K
Q110	6.5K	3.4K	100K	3.5K	1.5K	1.5K
Q111	0	0	900Ω	2.8K	6.7K	4K
Q112	0	0	20K	1.1K	6.5K	3K
Q113	1.5K	1.4K	3K	4K	24K	3K
Q114	1.6K	1.5K	3.2K	4.5K	34K	6K
Q115	1.6K	1.5K	3.4K	6K	∞	11K
Q116	1.5K	1.9K	6K	4.2K	3.4K	4.4K
Q117	1.6K	2.1K	2.4K	3.8K	6.2K	4K
Q118	200Ω	200Ω	1.3K	5.1K	6.5K	6.5K
Q119	190Ω	190Ω	1.3K	2.4K	1.3K	4.5K
Q120	0	0	1K	2.9K	1.3K	2.3K

AUTOMATIC MODULE HB-25580 VOLTAGE TABLE

Insert Automatic Module into Model 990. All voltages measured with respect to Common, Amplitude, Level and Slope fully CW. AUTO/MANUAL in AUTO.

	Treating Switch . . . . ON Run/Stop . . . . . STOP			Treating Switch . . . . OFF Run/Stop . . . . . RUN		
Transistor	**Emitter**	**Base**	**Collector**	**Emitter**	**Base**	**Collector**
Q101	-0.61	0	+10.5			
Q102	-0.61	0	+10.5			
Q103	+11	+10.5	+0.9			
Q104	-9.5	-9.0	+0.9			
Q105	-0.57	0	+10.5	+3.4		+2.7
Q106	-0.57	0	+11	+3.3		-8.9
Q107	+11	+11	-8.5			
Q108	-9.8	-9.0	-9.5			
Q109	-0.15	-8.7	+11.0	-9.2		
Q110	-8.7	-9.5	-10.5	-9.3		
Q111	0	+0.7	+0.05		-4.6	+2.7
Q112	0	-0.8	-0.15		0	-9.2
Q113	-10.5	-9.6	-10.5			0
Q114	-10	-9.4	-10			-9
Q115	-10.2	-10	+11		-9	-9.8
Q116	+11	+10.4	+11			-7.7
Q117	+11	+11	+10.5			
Q118	+0.77	+0.8	+11	+0.95	+1.65	+1
Q119	+0.77	+1.45	+0.8	+0.95	+0.7	+1.65
Q120	0	-0.53	+1.45			+0.7

CAUTION: High voltage present inside dust cover.

Table of Replaceable Parts

MODEL 990 MAGNETREATER

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	RFL PART NO.
C1, 4	CAPACITOR, elect: 500μF 50V.	HA-13569
C2	CAPACITOR, silicon, mica: 91pF 5%, 500V.	H-1080-329
C3	CAPACITOR, tantalum: 15μF 20%, 35V.	H-1007-654
C5, 6	CAPACITOR, ceramic: .005μF +80 -20%, 100V.	H-1007-751
C7	CAPACITOR, ceramic: 0.47μF +80 - 20%, 25V.	HA-13579
C8, 16	CAPACITOR, tantalum: 1μF 20%, 35V.	H-1007-496
C9	CAPACITOR, ceramic: 0.05μF +80 -20%, 25V.	H-1007-647
C10, 19	CAPACITOR, ceramic: .02μF +80 -20%, 25V.	H-1007-754
C11, 14	CAPACITOR, ceramic: .022μF 20%, 12V.	H-1007-755
C12	CAPACITOR, tantalum: 2.2μF 10%, 20V.	H-1007-752
C13	CAPACITOR, ceramic: .05μF +80 -20%, 25V.	H-1007-647
C15	CAPACITOR, tantalum: 22μF 20%, 15V.	H-1007-656
C17, 18	CAPACITOR, 50μF 600V.	HA-1609
C20	CAPACITOR, ceramic: .001μF 10%, 1000V.	H-1007-235
CR1, 2, 4, 5, 7, 8, 10, 11, 12, 13 & 23 thru 30	DIODE, silicon: 200PIV 1A 25°C.	HA-17995
CR3	DIODE, zener: 6.2V 10%, 1 W.	HA-26121
CR6, 9	DIODE, zener: 13V 10%, 1 W.	HA-26127
CR14 thru 21	DIODE, silicon: 600PIV ½A.	HB-12946
CR22	DIODE, zener: Z4X122B.	HA-18788
CR31	DIODE, silicon: 600PIV 15A DC 300A.	HA-26128
CR32, 33	RECTIFIER, silicon C106B1	HA-26136
CR34	RECTIFIER, silicon 2N2899	HA-24452
F1	FUSE 2A 3AG 250V.	HA-1289
I 1	LIGHT INDICATOR, neon red	HA-13567
I 2	LIGHT INDICATOR, neon yellow	HA-14222
Q1, 3	TRANSISTOR, silicon: PNP 40V 2N3905	HA-24087
Q2	TRANSISTOR, PWR: PNP 2N2063A	HA-17511
Q4, 16	TRANSISTOR, silicon: NPN 2N697	HA-18598

Table of Replaceable Parts

MODEL 990 MAGNETREATER

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	RFL PART NO.
Q5	TRANSISTOR, 2N2160	HA-26129
Q6, 10 thru 18	TRANSISTOR, silicon: NPN 40V.	HA-25567
R1	RESISTOR, WW: 25 ohms 5%, 50 W.	H-1100-33
R2	RESISTOR, WW: 200 ohms 5%, 3¼ W.	H-1220-31
R3	RESISTOR, WW: 2500 ohms 5%, 1½ W.	H-1100-423
R4	RESISTOR, comp.: 56 ohms 5%, ½ W.	H-1009-236
R5, 6	RESISTOR, WW: 2K 5% 1½ W.	H-1100-422
R7, 8	RESISTOR, WW: 1K 5%, 1½ W.	H-1100-429
R9, 11	RESISTOR, comp.: 220 ohms 5%, ½ W.	H-1009-387
R10, 21, 42, 45, 47	RESISTOR, comp.: 2.2K 5%, ¼ W.	H-1009-767
R12	RESISTOR, comp.: 470 ohms 5%, ½ W.	H-1009-458
R18, 19, 20, 22	RESISTOR, comp.: 15K 5%, ¼ W.	H-1009-816
R23	RESISTOR, metal film: 2000 ohms 5%, 2 W.	H-1510-780
R24	RESISTOR, metal film: 130K 5%, 2 W.	H-1510-781
R25	RESISTOR, metal film: 68K 5%, 2 W.	H-1510-782
R26	RESISTOR, metal film: 33K 5%, 2 W.	H-1510-783
R27	RESISTOR, metal film: 18K 5%, 2 W.	H-1510-784
R28	RESISTOR, metal film: 8.2K 5%, 2 W.	H-1510-785
R29	RESISTOR, metal film: 1K 5%, 2 W.	H-1510-786
R30	RESISTOR, comp.: 330 ohms 5%, ½ W.	H-1009-362
R31	RESISTOR, variable: 5K 10%, 3 W.	HA-26131
R32, 34	RESISTOR, metal film: 10K 5%, 2 W.	H-1510-787
R33	RESISTOR, variable: 2.5K 10%, 3 W.	HA-26132
R35	RESISTOR, comp.: 1K 5%, ¼ W.	H-1009-612
R37, 48, 58	RESISTOR, comp.: 47K 5%, ¼ W.	H-1009-792
R38, 44	RESISTOR, comp.: 47 ohms 5%, ¼ W.	H-1009-832
R39, 40, 51, 60	RESISTOR, comp.: 4.7K 5%, ¼ W.	H-1009-787
R41, 46	RESISTOR, comp.: 68K 5%, ¼ W.	H-1009-794

Table of Replaceable Parts

MODEL 990 MAGNETREATER

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	RFL PART NO.
R43	RESISTOR, comp.: 56K 5%, ¼ W.	H-1009-793
R49, 59	RESISTOR, comp.: 22K 5%, ¼ W.	H-1009-789
R50	RESISTOR, variable, 50K 10%, 2 W.	HA-26130
R52, 56	RESISTOR, comp.: 220K 5%, ¼ W.	H-1009-796
R53, 55	RESISTOR, comp.: 24K 5%, ¼ W.	H-1009-790
R54, 57	RESISTOR, comp.: 3K 5%, ¼ W.	H-1009-765
R61	RESISTOR, metal film: 68K 5%, 2 W.	H-1510-782
R62	RESISTOR, WW: 800 ohms 5%, 50 W.	H-1100-547
R63	RESISTOR, metal film: 130K 5%, 2 W.	H-1510-781
R64	RESISTOR, WW: 2 ohms 5%, 11 W.	H-1100-548
S1	SWITCH, toggle DPDT 2 POS.	HA-26137
S2	SWITCH, rotary	HB-26138
S3	SWITCH, rotary	HB-26139
S4	SWITCH, toggle SPST	HA-3709
S5	SWITCH, push-button SPDT	HA-26133
T1	TRANSFORMER, power	HC-26104
T2	TRANSFORMER, pulse	HA-24277
T3	TRANSFORMER, charging poten.	HC-26103

Table of Replaceable Parts

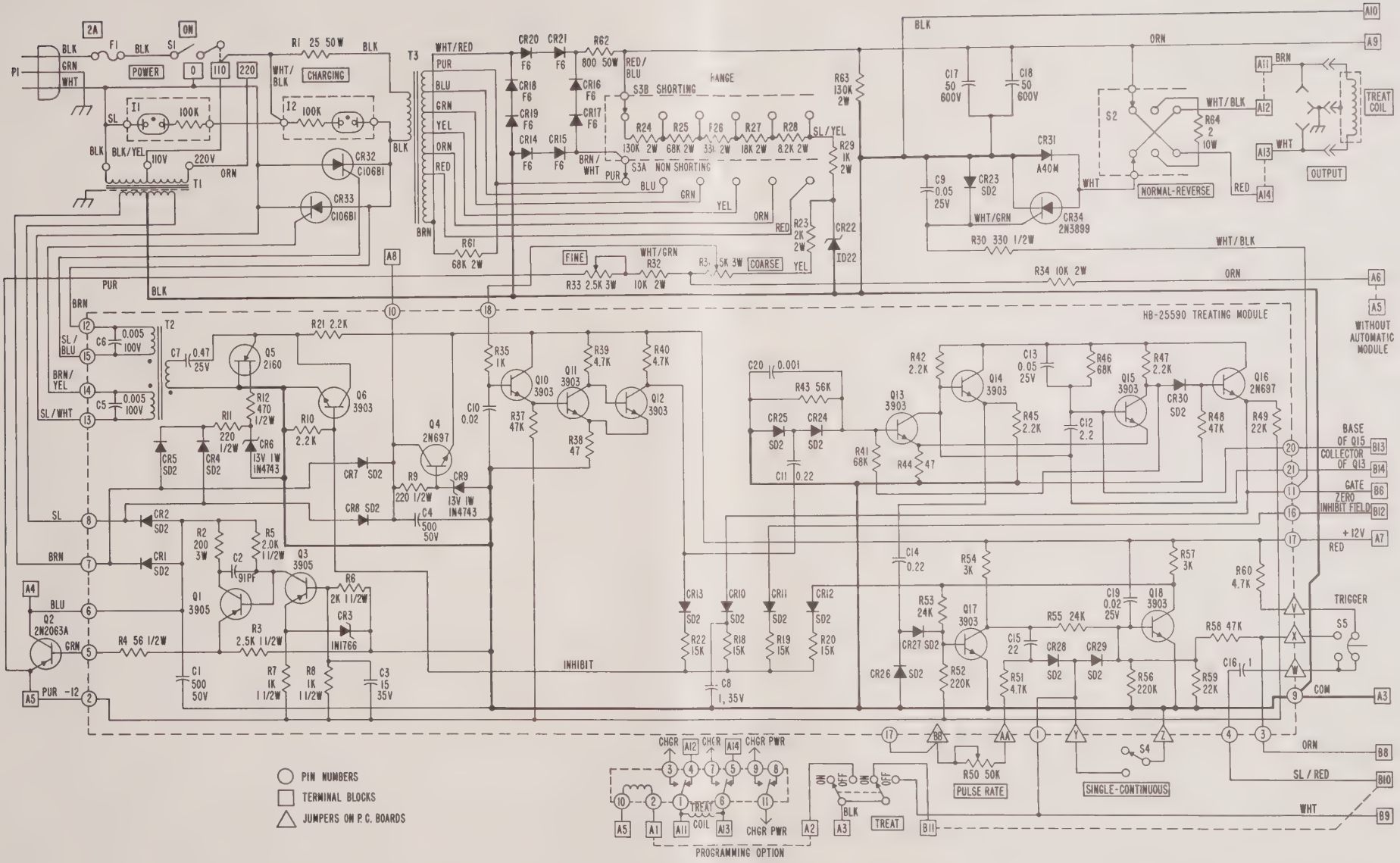
AUTOMATIC MODULE HB-25580

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	RFL PART NO.
C101	CAPACITOR, mylar: 0.560μF 2%, 100V.	H-1007-452
C102	CAPACITOR, 0.82μF 2%, 200V.	H-1007-551
C103	CAPACITOR, .05μF 80% 20%, 25V.	H-1007-647
C104, 105	CAPACITOR, 0.510μF 2%, 100V.	H-1007-450
C106	CAPACITOR, polarized: .0045μF 2%, 100V.	H-5115-18
C107, 108	CAPACITOR, tantalum: 22μF 10%, 35V.	H-1007-666
C109	CAPACITOR, tantalum: 2.2μF 20%, 20V.	H-1007-645
C110, 111	CAPACITOR, tantalum: 1μF 20%, 35V.	H-1007-496
C112	CAPACITOR, ceramic: 0.47μF 80% 20%, 25V.	HA-13579
C114	CAPACITOR, tantalum: 120μF 20%, 10V.	H-1007-659
CR101, 102	DIODE, silicon SD2	HA-17995
CR103	DIODE, zener: 6.2V 10%, 1 W.	HA-26121
I101	LAMP CART, Incandescent red	HA-17505
I102	LAMP CART, Incandescent green	HA-26122
K103, 104	RELAY, DPDT 2000 ohm	HA-18574
L101	CHOKE ASSEMBLY, .4568 H.	HB-25593
Q101, 102, 104, 105, 106, 108, 109, 111, 113, 114, 118, 119, 120	TRANSISTOR, silicon: NPN 2N3903-18	HA-25567
Q103, 107, 110, 112, 116 & 117	TRANSISTOR, silicon: PNP 2N3905-18	HA-24087
Q115	TRANSISTOR, silicon: NPN 2N2102	HA-22678
R101, 102, 106, 110, 136 & 148	RESISTOR, comp.: 10K 5%, ¼ W.	H-1009-742
R103	RESISTOR, variable, WW: 1K 5%, 2 W.	HA-26123
R104, 147, 149, 154	RESISTOR, comp.: 4.7K 5%, ¼ W.	H-1009-787
R105, 108, 116, 132, 141	RESISTOR, comp.: 1K 5%, ¼ W.	H-1009-612
R107, 131	RESISTOR, comp.: 1.5 Meg 5%, ¼ W.	H-1009-799
R109, 133	RESISTOR, comp.: 2.7K 5%, ¼ W.	H-1009-762
R11, 118, 124, 128, 137 & 143	RESISTOR, comp.: 2.2K 5%, ¼ W.	H-1009-767

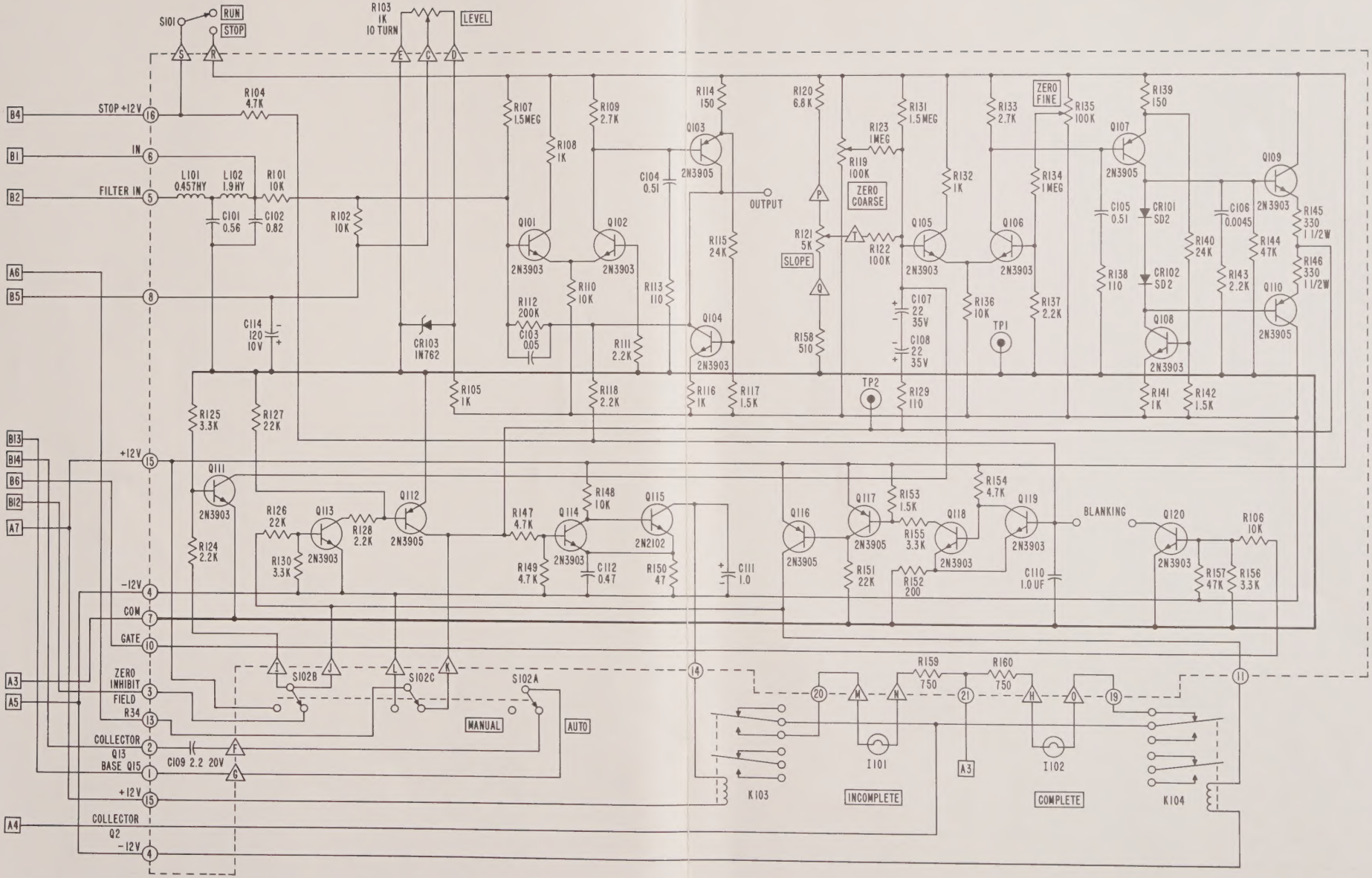
Table of Replaceable Parts

AUTOMATIC MODULE HB-25580

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	RFL PART NO.
R112	RESISTOR, comp.: 200K 5%, ¼ W.	H-1009-803
R113, 129, 138	RESISTOR, comp.: 1100 MM 5%, ¼ W.	H-1009-784
R114, 139	RESISTOR, comp.: 1500 MM 5%, ¼ W.	H-1009-759
R115, 140	RESISTOR, comp.: 24K 5%, ¼ W.	H-1009-790
R117, 142, 153	RESISTOR, comp.: 1.5K 5%, ¼ W.	H-1009-822
R119, 135	RESISTOR, variable, comp.: 100K 30%, 0.25 W.	HA-26124
R120	RESISTOR, comp.: 6.8K 5%, ¼ W.	H-1009-890
R121	RESISTOR, variable: 5K 10%, 2 W.	HA-26125
R122	RESISTOR, comp.: 100K 5%, ¼ W.	H-1009-795
R123, 134	RESISTOR, comp.: 1 meg. 5%, ¼ W.	H-1009-798
R125, 130, 155, 156	RESISTOR, comp.: 3.3K 5%, ¼ W.	H-1009-729
R126, 127, 151	RESISTOR, comp.: 22K 5%, ¼ W.	H-1009-789
R114, 157	RESISTOR, comp.: 47K 5%, ¼ W.	H-1009-792
R145, 146	RESISTOR, WW: 330 ohms 5%, 1½ W.	H-1100-544
R150	RESISTOR, comp.: 47 ohms 5%, ¼ W.	H-1009-832
R152	RESISTOR, comp.: 200 ohms 5%, ¼ W.	H-1009-785
R158	RESISTOR, comp.: 510 ohms 5%, ¼ W.	H-1009-807
R159, 160	RESISTOR, comp.: 750 ohms 5%, ¼ W.	H-1009-779
S101	SWITCH, toggle SPDT	HA-25579
S102	SWITCH, toggle 3 PDT	HA-26126



Schematic Diagram of Model 990 Magnetreater.



Schematic Diagram of Automatic Module.

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MP MASTER

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